Pilot Testing Geological Sequestration of CO_2 in California

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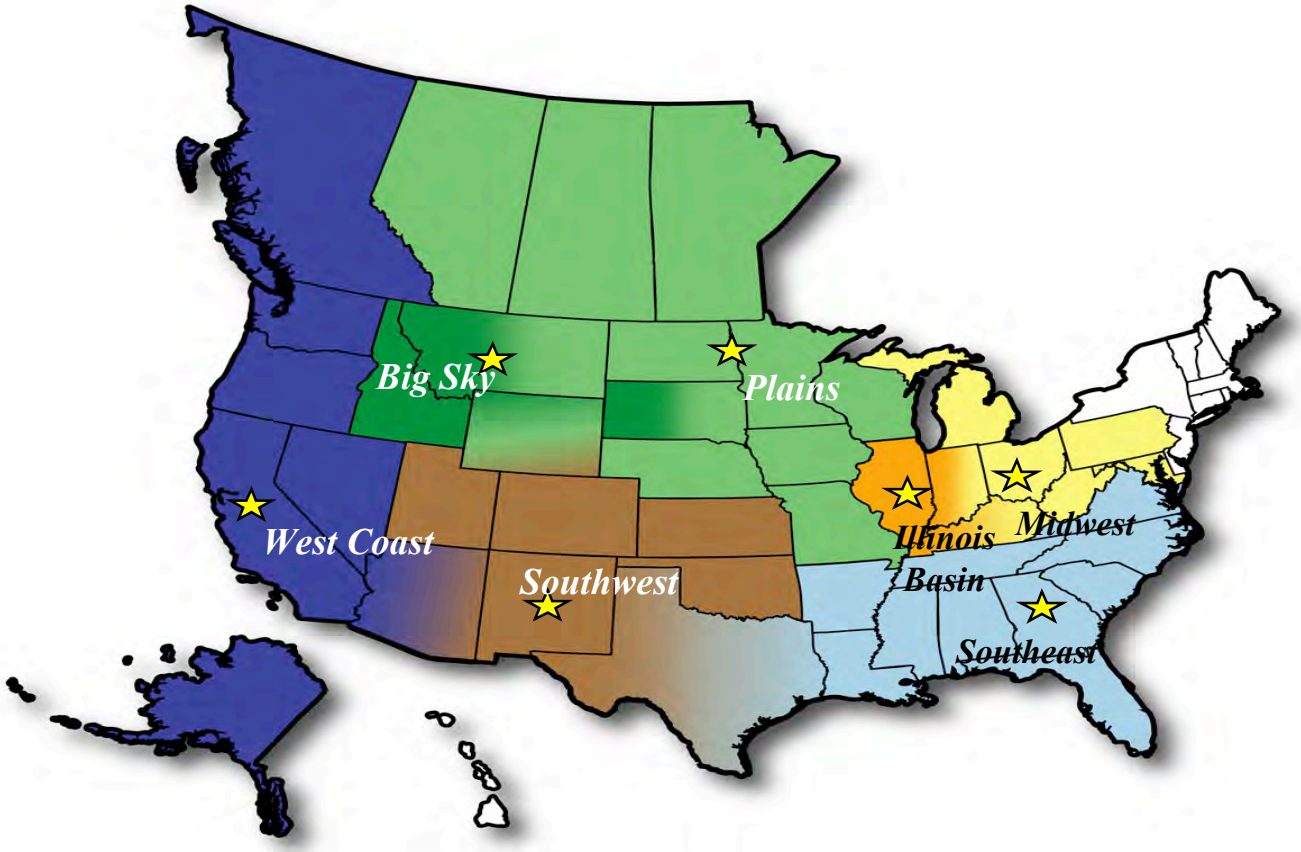
WESTCARB is One of Seven Regional Sequestration Partnerships

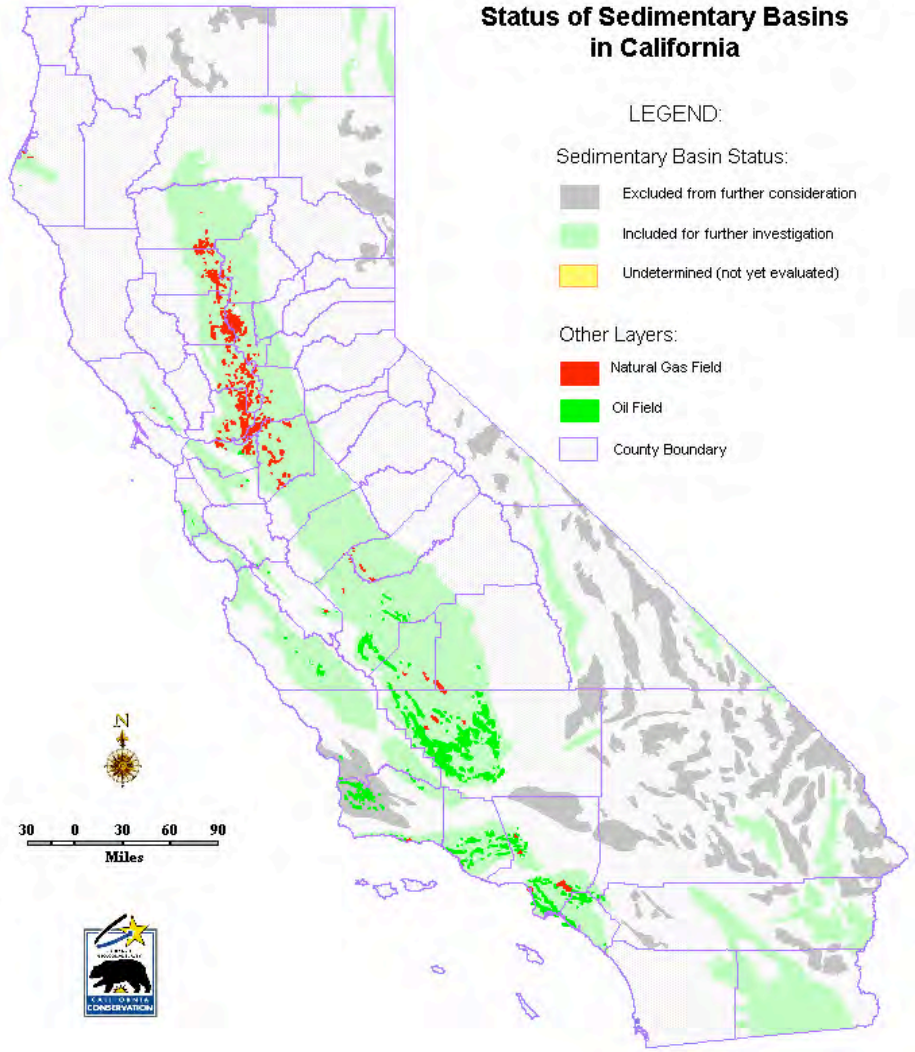
1. Where are the sources of CO_2 and how much is there?
2. Where can it be stored?
3. How much will it cost?
4. Will it be safe?



7 Regional Carbon Sequestration Partnerships

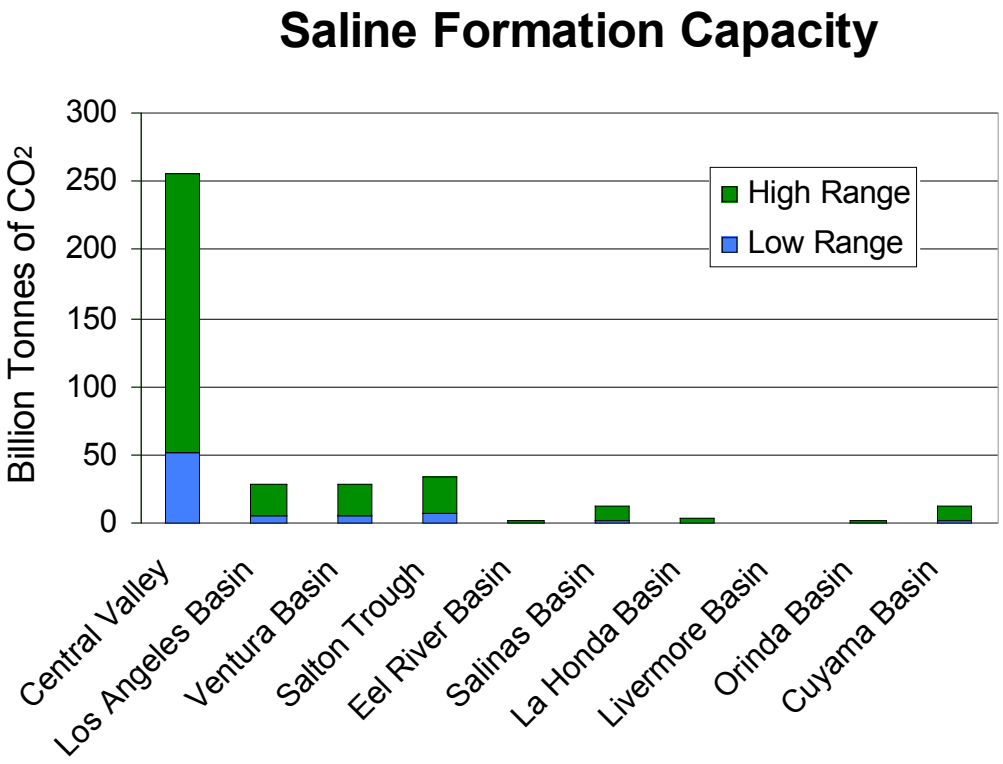
Preliminary Screening Shows California Has Many Options for Geological Sequestration

- Oil reservoirs
  - 121 fields
- Gas reservoirs
  - 128 fields
- Saline formations
  - 27 basins



CO_2 Storage Capacity in California

- Oil Reservoirs
  - 3.8 billion tonnes
- Gas Reservoirs
  - 1.8 billion tonnes
- Saline Formations
  - 75 to 300 billion tonnes



Site Selection Tool Screening Criteria

Primary Containment

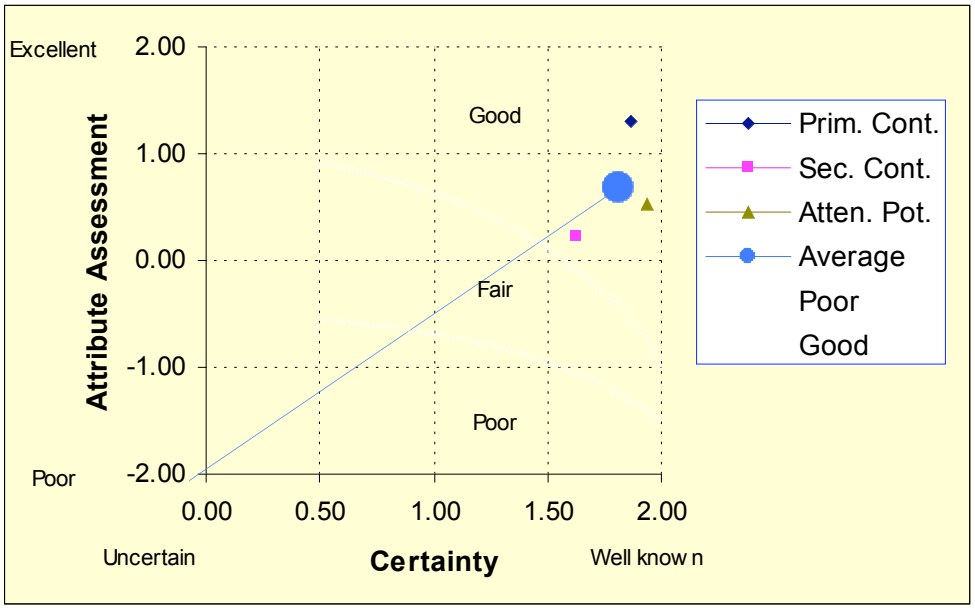
- Primary Seal
- Depth
- Reservoir

Secondary Containment

- Secondary Seal
- Shallower Seal(s)
- Reservoir

Attenuation Potential

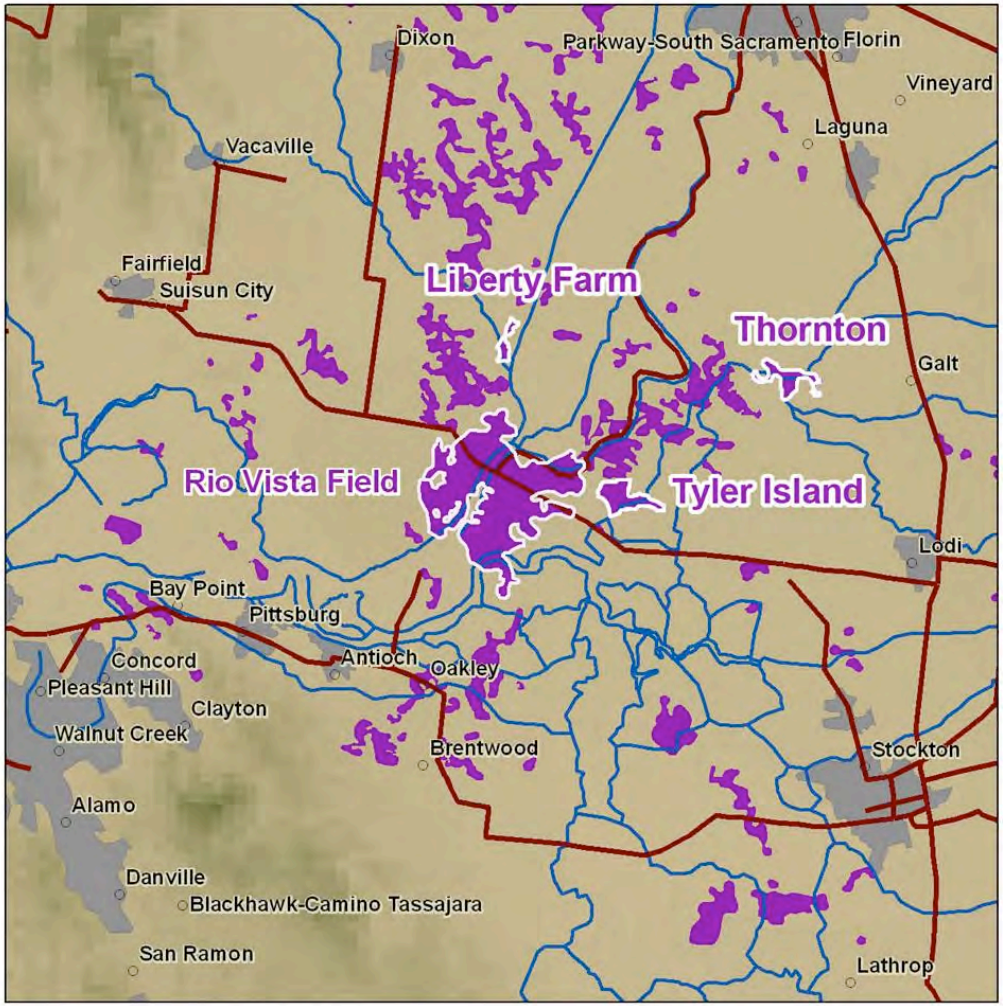
- Surface characteristics
- Hydrology
- Existing wells
- Faults



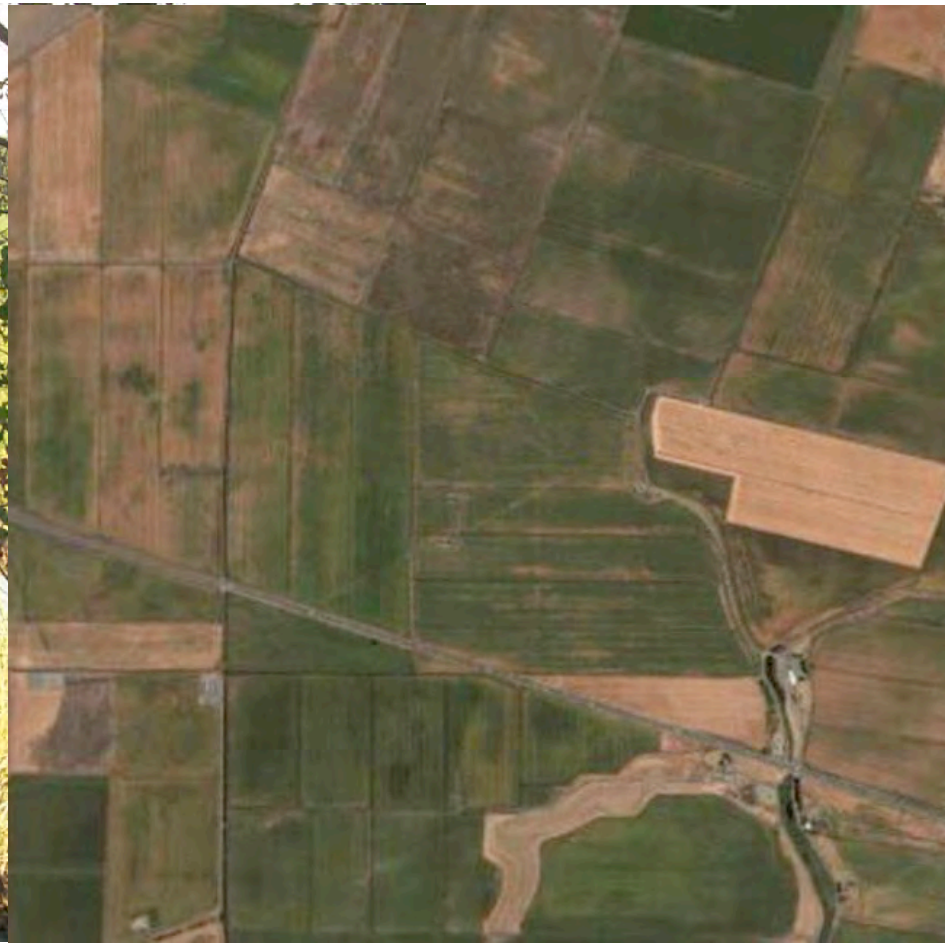
Sacramento Valley Gas Fields

Rosetta Geological Sequestration Project

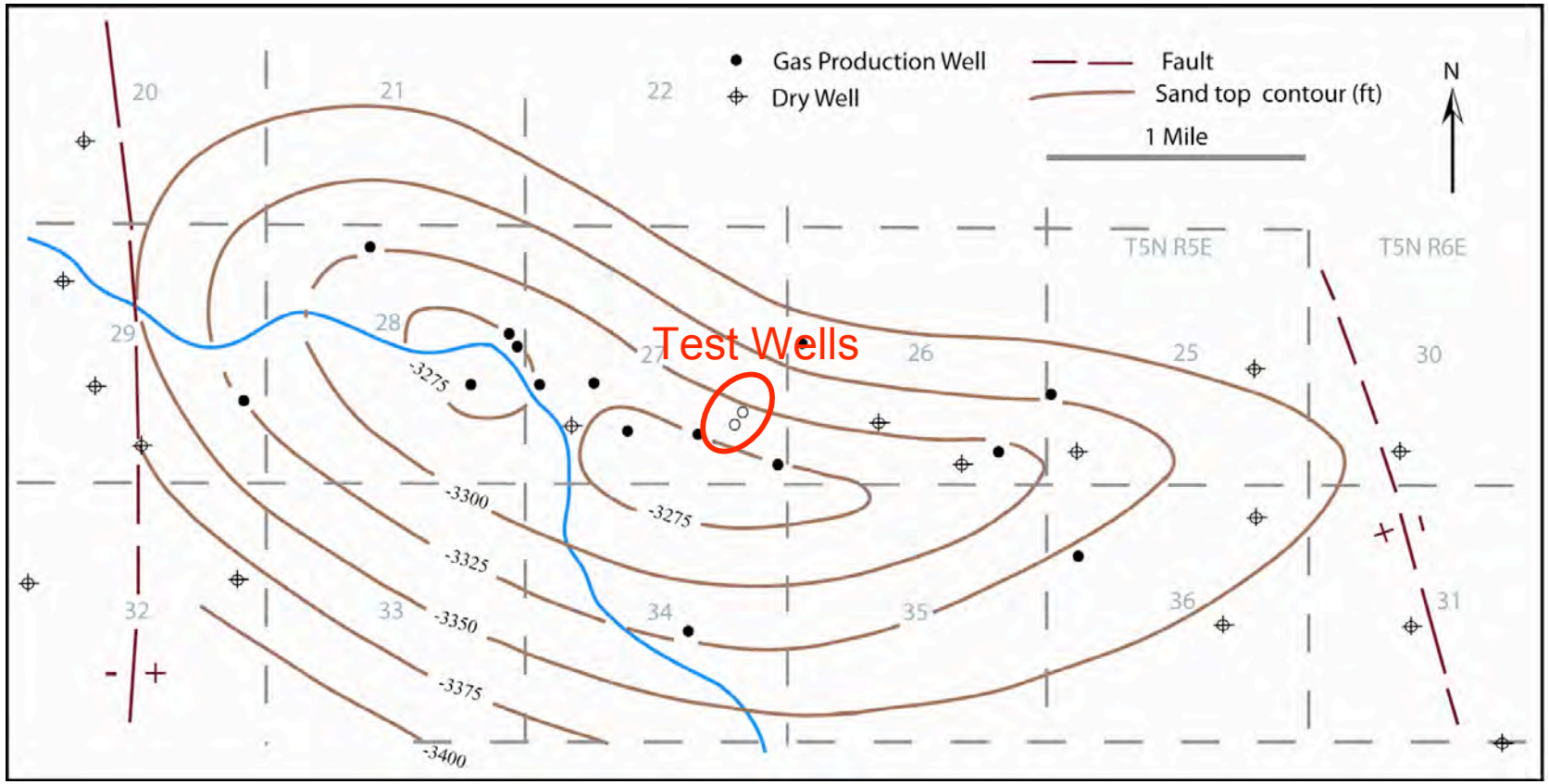
- Rosetta Resources partnership
- Test two of the most significant sequestration options
  - Gas reservoirs
  - Saline formations
- 3 Key Elements
  - Injection
  - Monitoring
  - Modeling



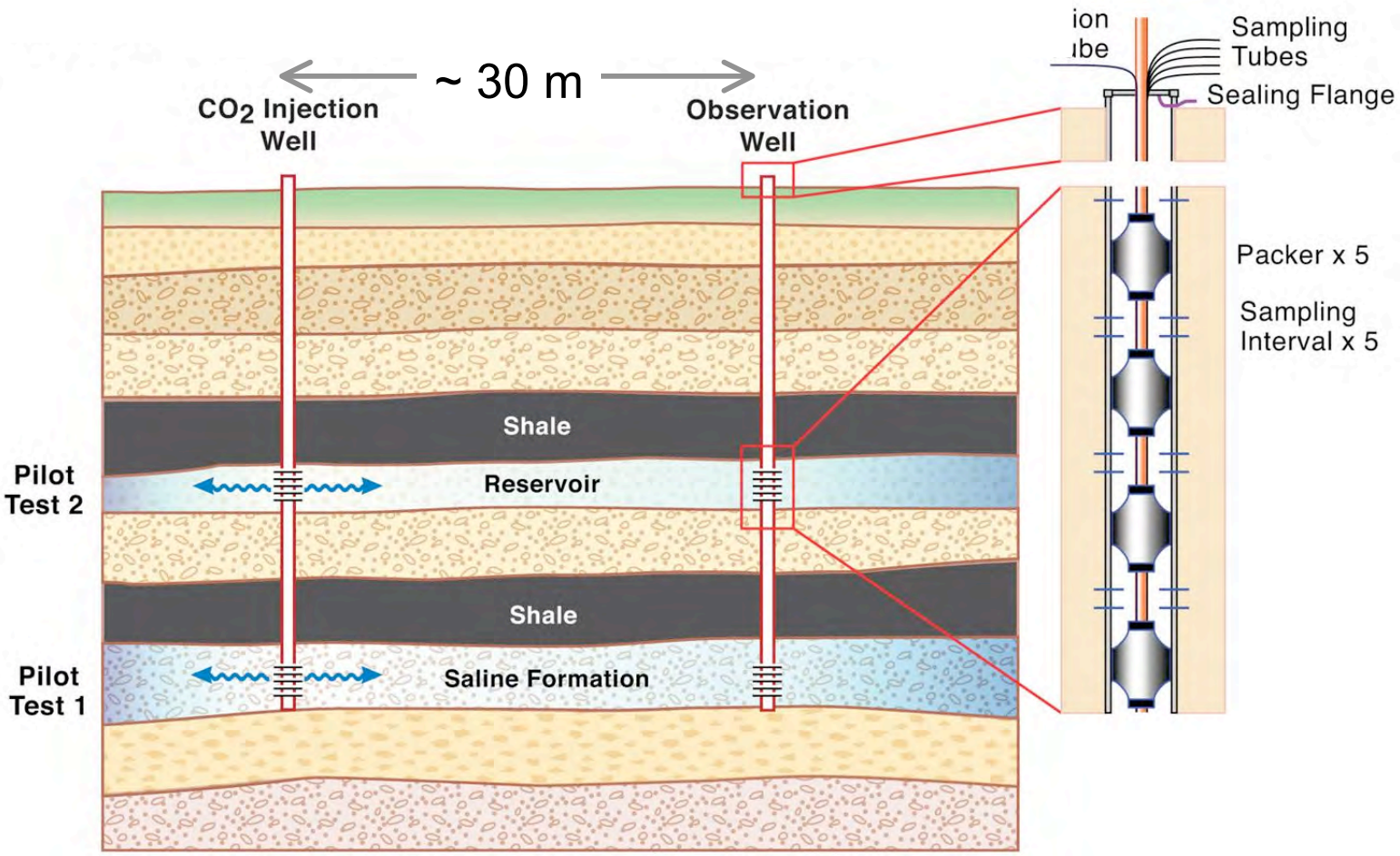
Rosetta Pilot Test Site



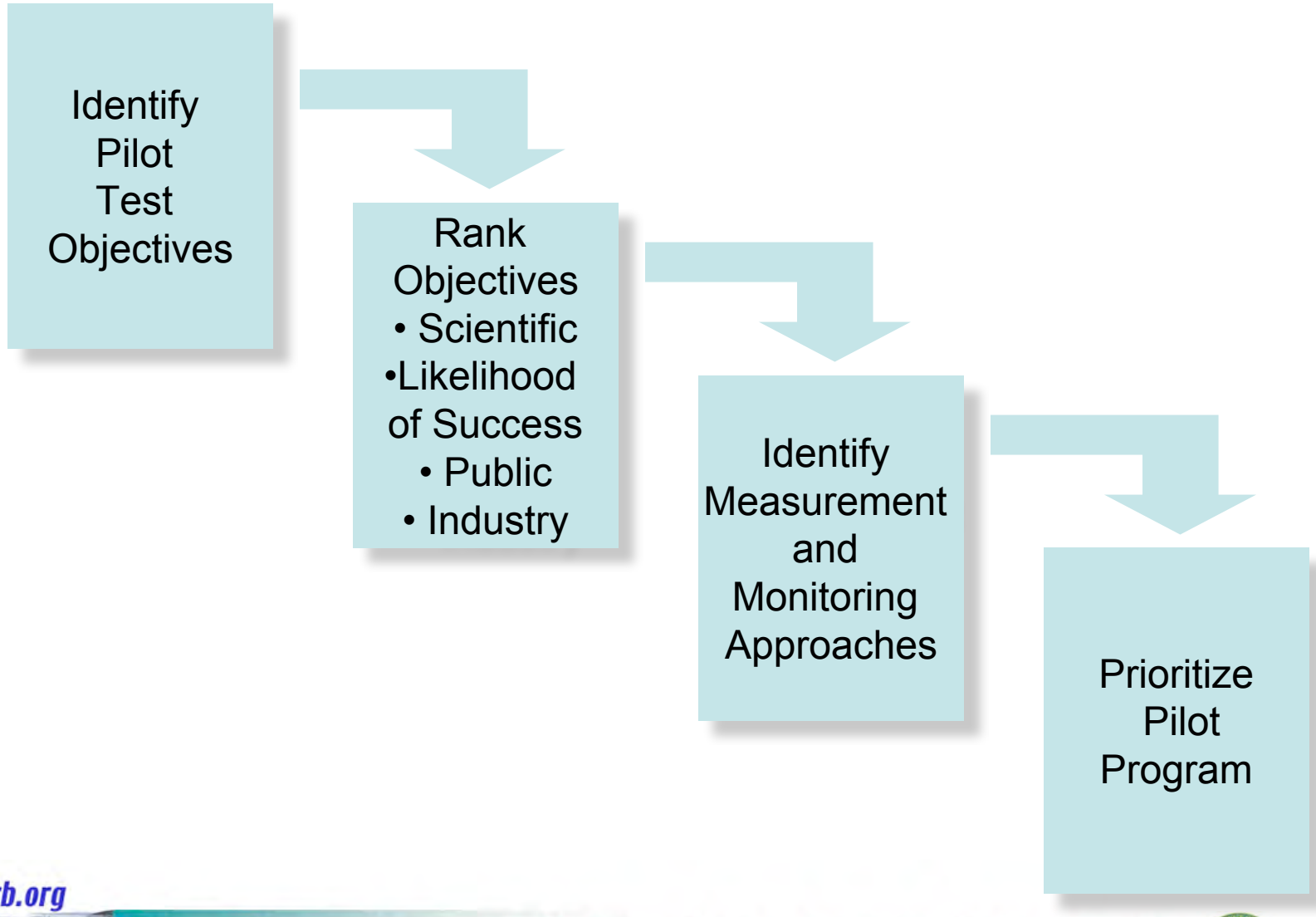
Thornton Gas Field Structure Map



Rosetta: Two-well Pilot Test



Pilot Project Priorities

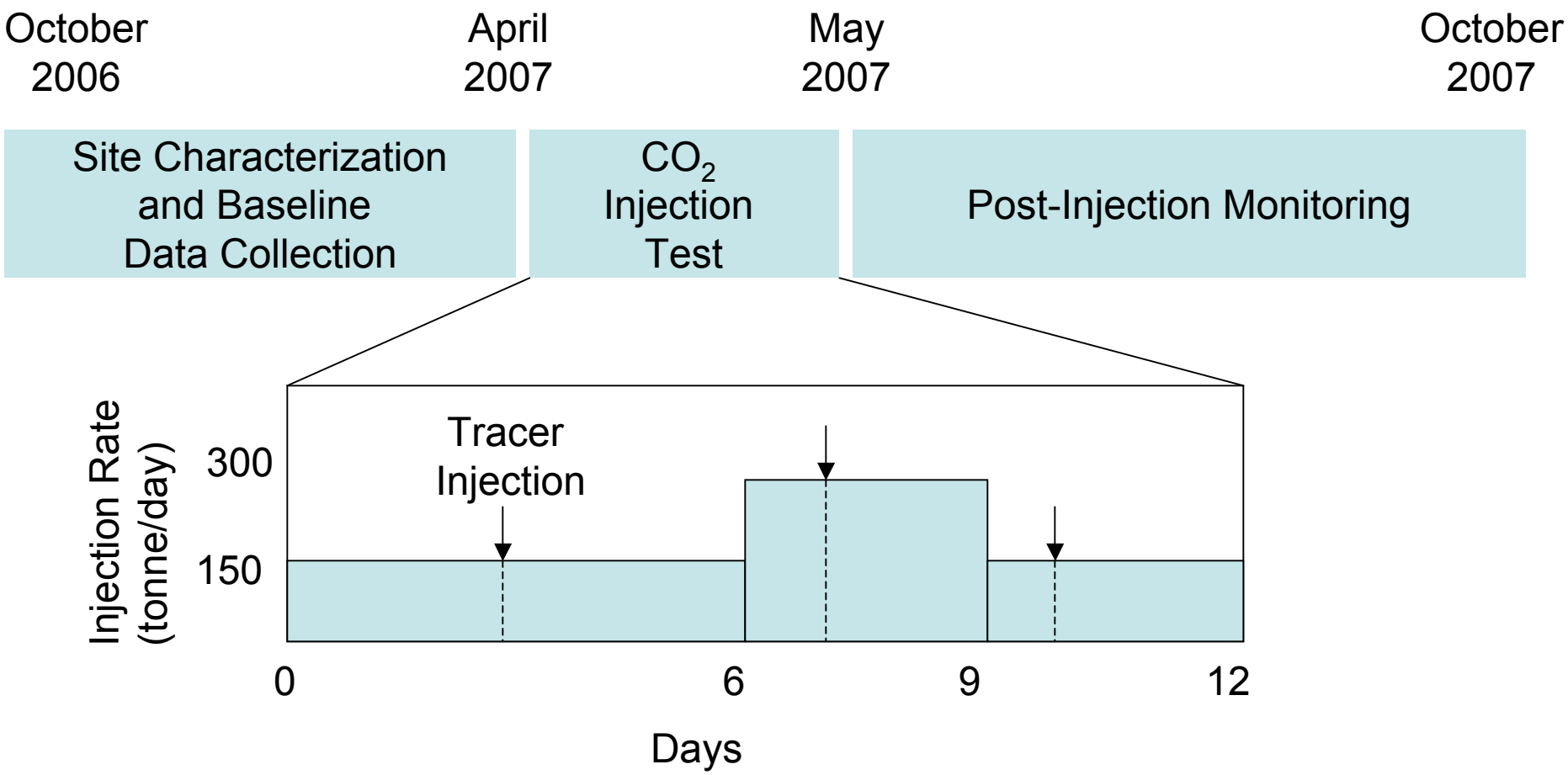


Saline Formation Pilot Test Objectives

- Assess seal integrity
  - Caprock
  - Faults
- Assess the spatial extent of the plume of injected CO_2
- Determine the storage capacity of the reservoir
- Determine the injectivity of the reservoir
- Evaluate environmental impacts
  - Abandoned wells
  - Groundwater

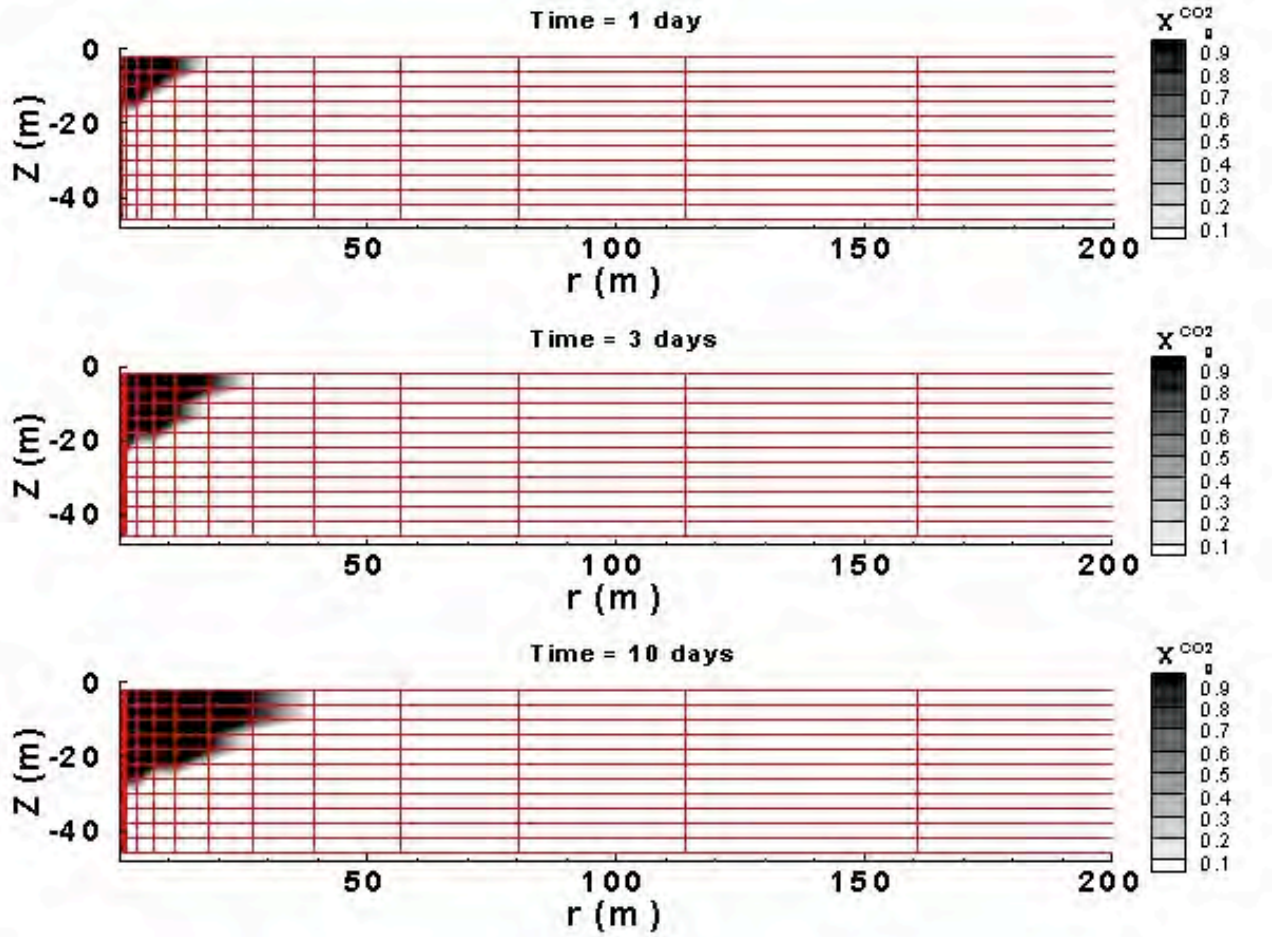
Prioritize Pilot Program

Saline Formation Pilot Test Program Schedule



Total Injection: 2,250 tonnes over 12 days

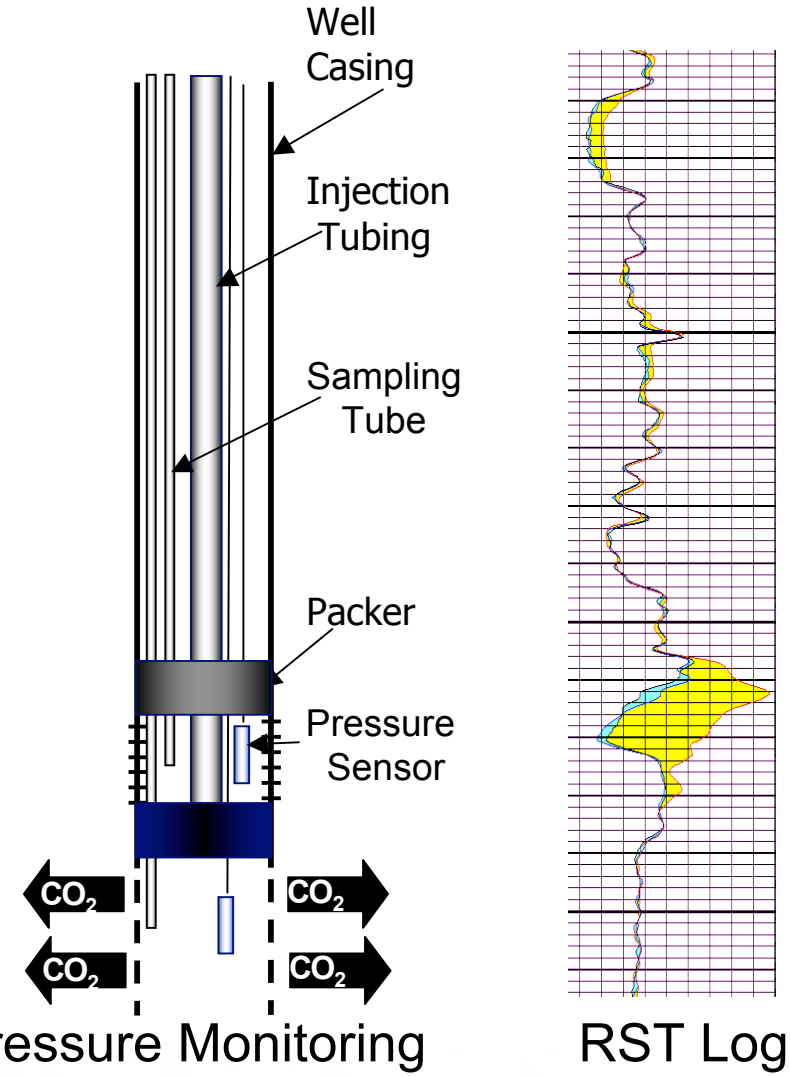
Predicted CO_2 Migration During the Pilot Tests



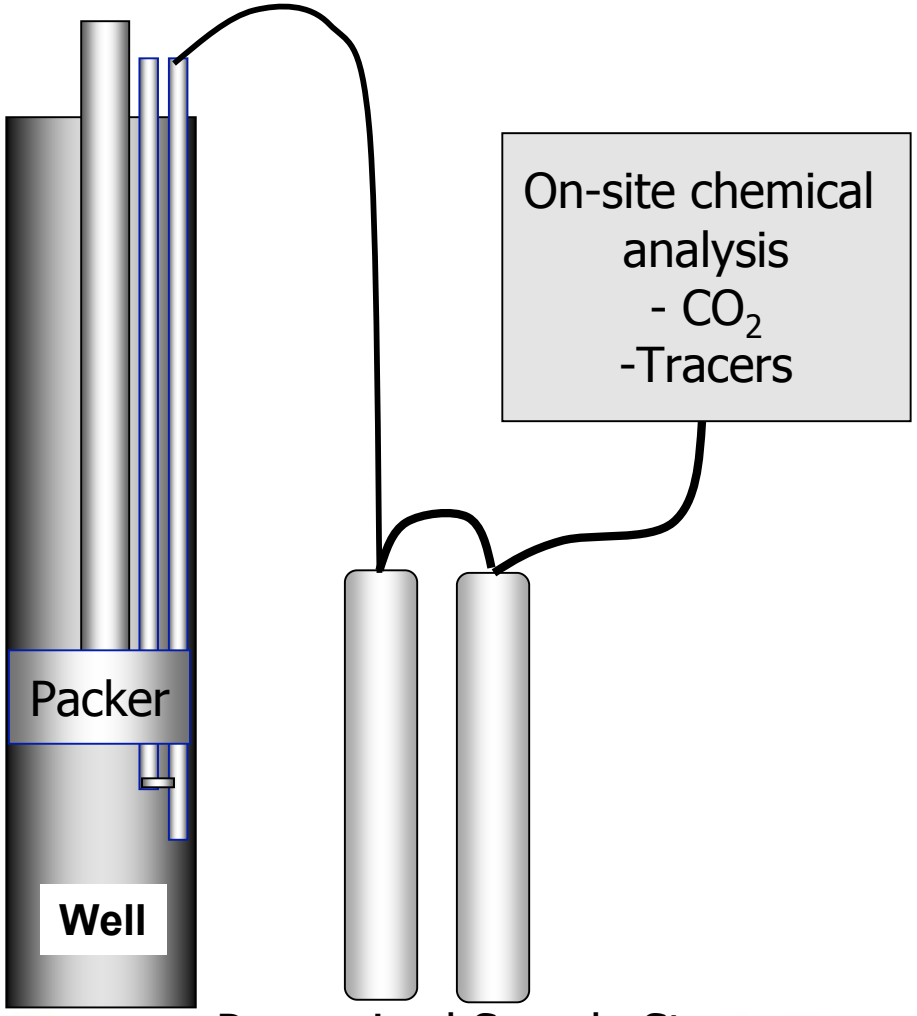
Saline Formation Test

Assess Seal Integrity

- Geomechanical analysis
  - Safe injection pressure
- Monitor pressure and water quality in a shallow formation above injection zone
- Obtain RST logs from injection and observation wells before and after CO_2 injection

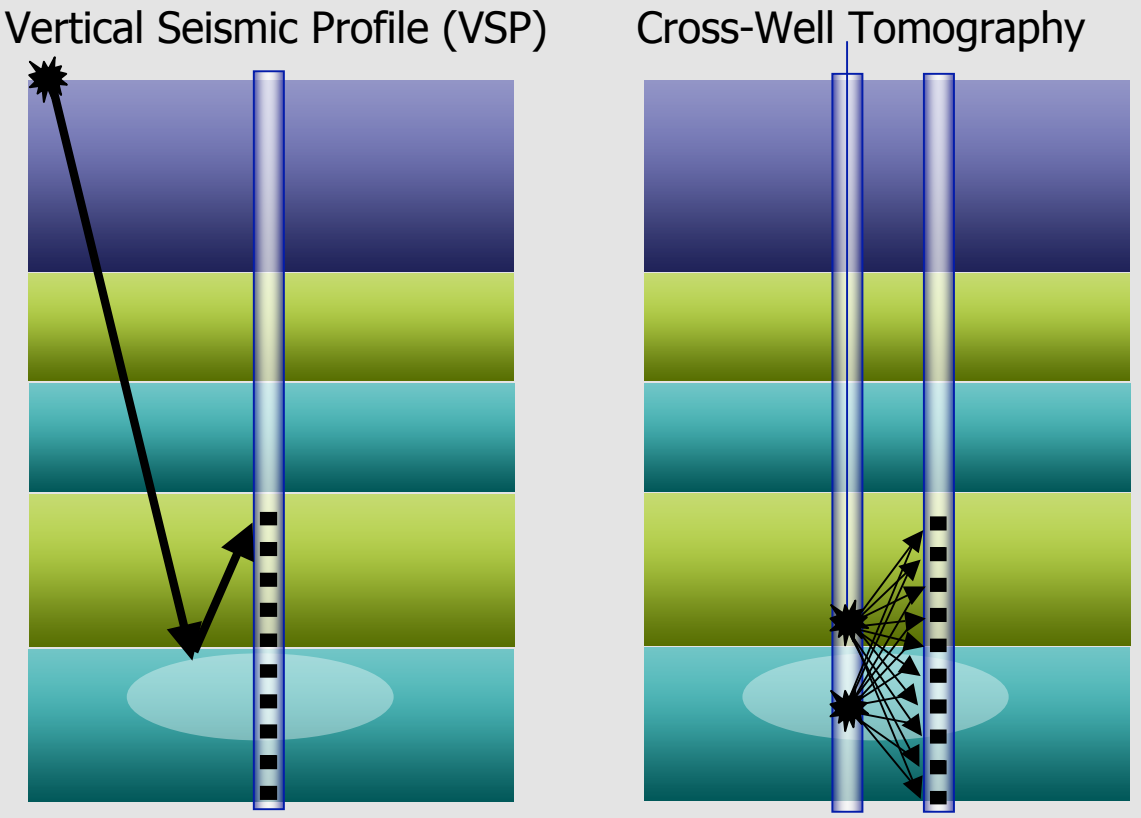


Fluid and Gas Sampling: U-tube Sampler

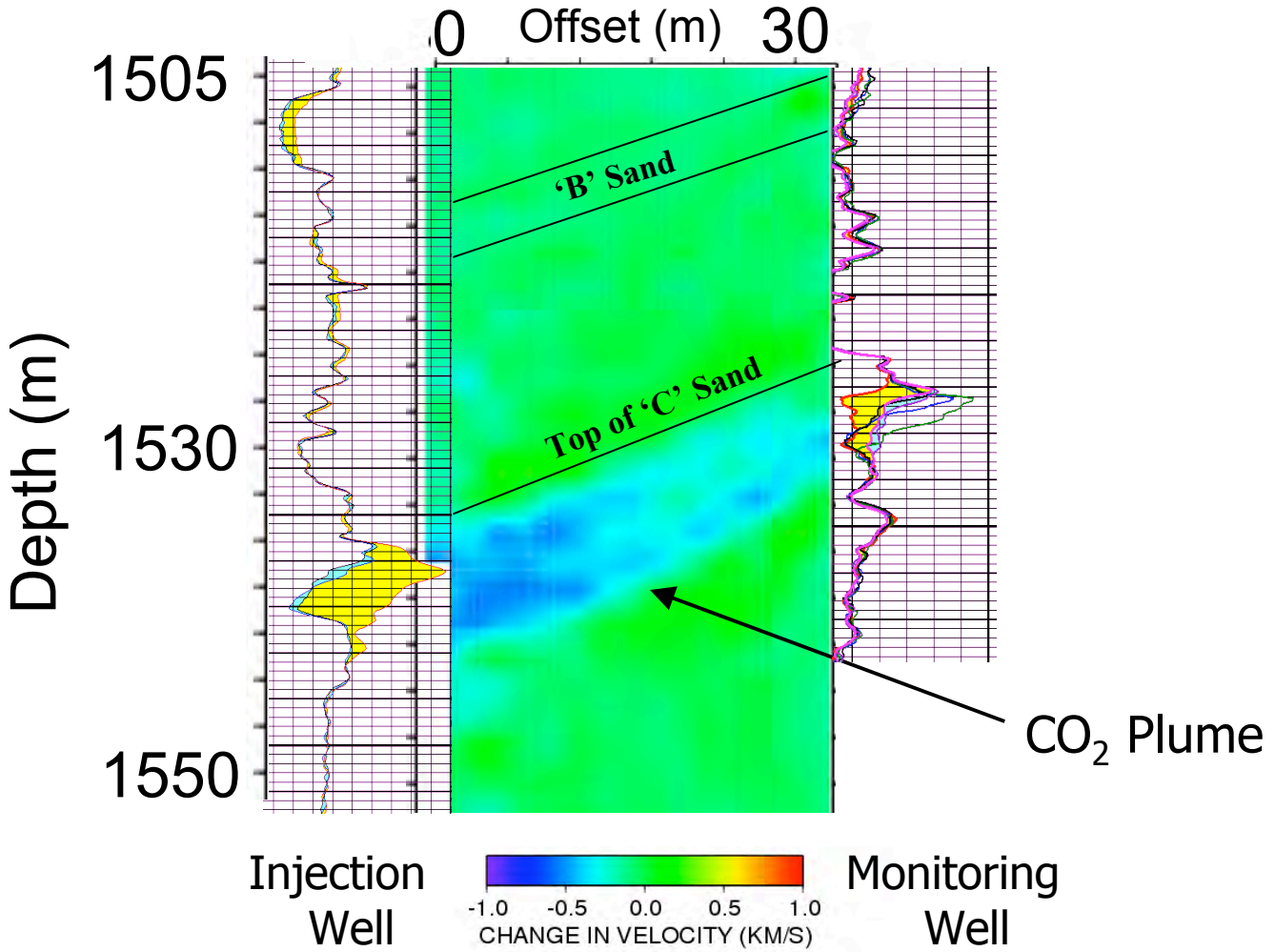


Assess the Spatial Extent of the Plume of Injected CO_2

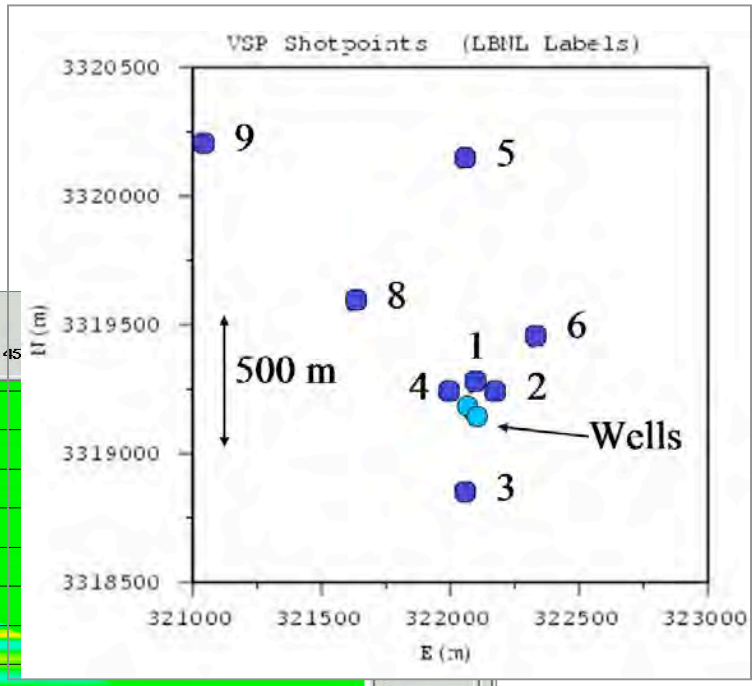
- Seismic imaging
  - Vertical seismic profiling (VSP)
  - Cross-well seismic
- Fluid sampling

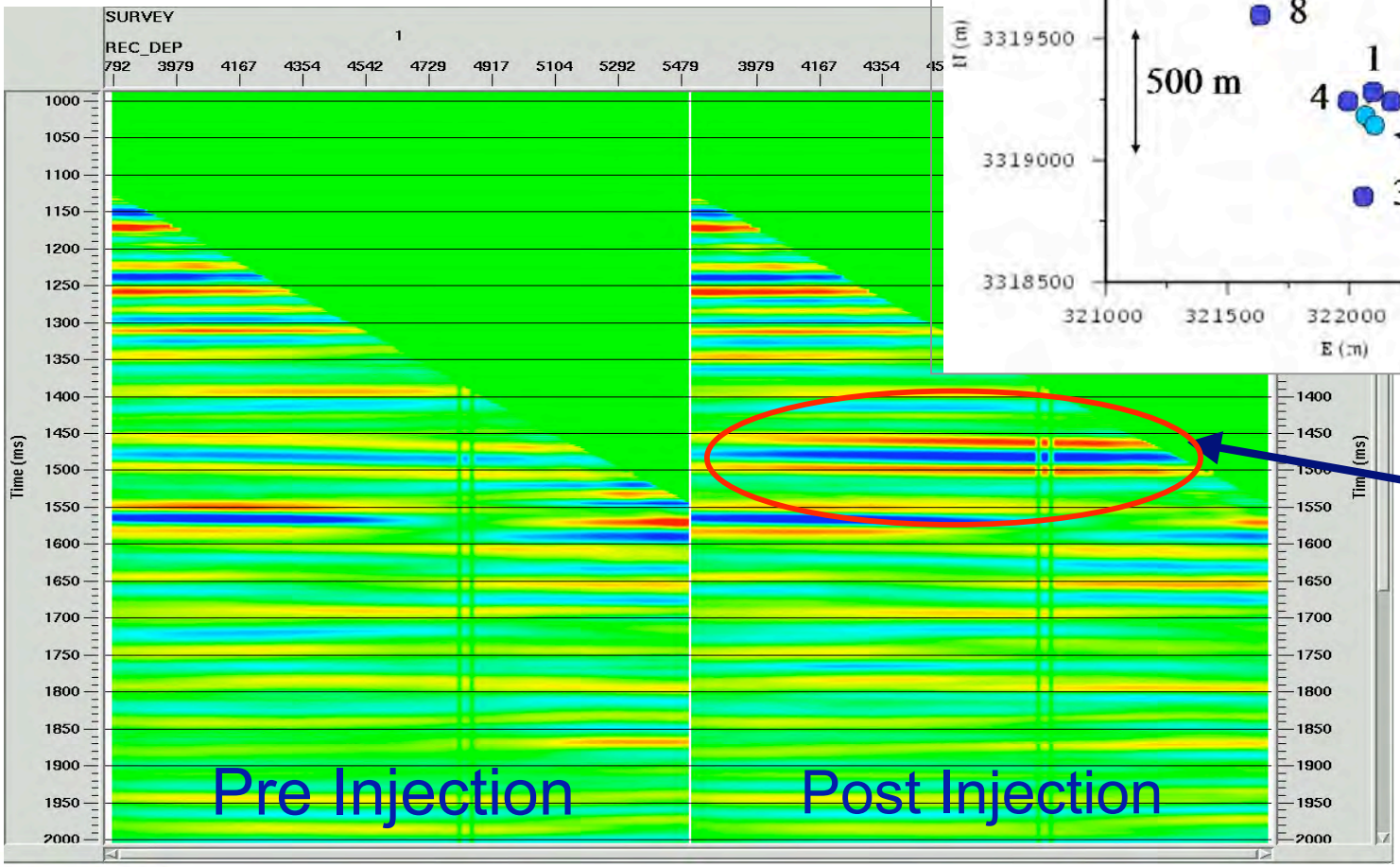


Frio Formation: Cross-well Seismic Data



Vertical Seismic Profile Data





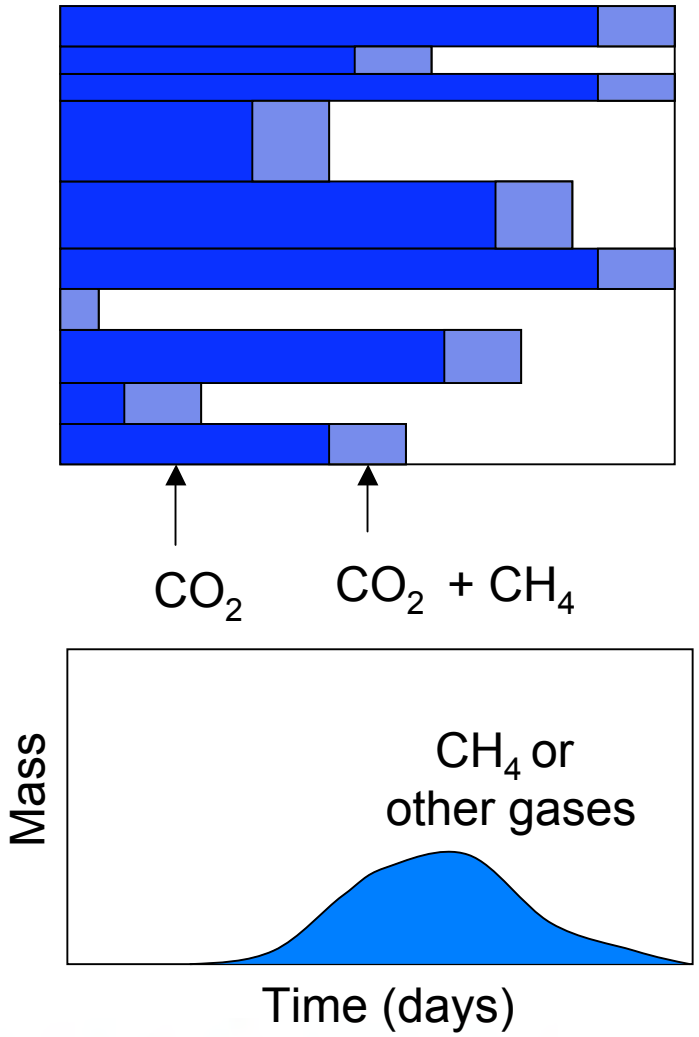
Two-way travel time

CO_2 Reflection

Data from Tom Daley, LBNL

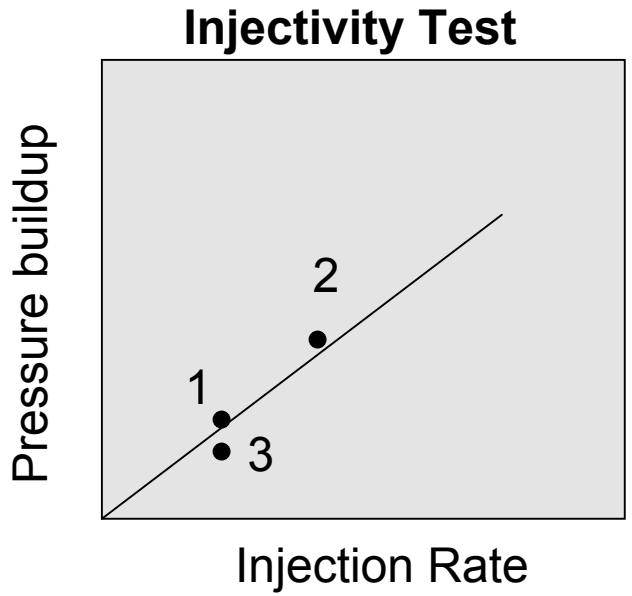
Assessment of Storage Capacity

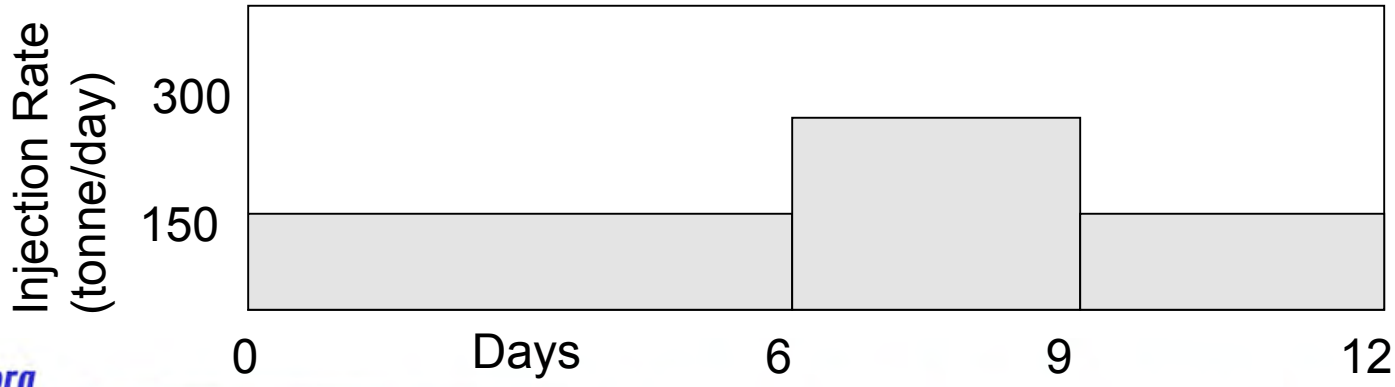
- Separate phase CO_2
  - Fluid sampling
  - Seismic imaging
  - Introduced tracers
- Dissolved CO_2
  - Natural and introduced tracers



Determine the Injectivity of the Reservoir

- Inject CO_2 at two or more rates
- Measure pressure buildup in the formation

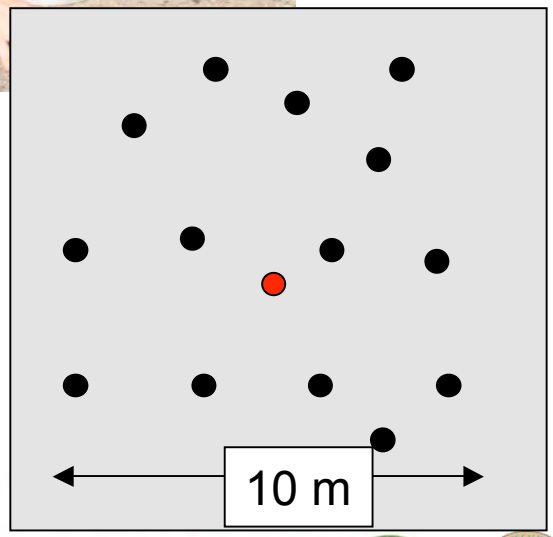




Evaluate Environmental Impacts of CO_2 Injection (Pre-, during and post-injection)

- Drill and sample shallow groundwater well
- Collect and analyze soil gas concentrations and fluxes in the vicinity of abandoned wells

Flux accumulation chamber



Gas flux sampling grid

Gas Reservoir Pilot Test Objectives

- Assess potential for EGR (Enhanced Gas Recovery)
  - Mixing between CO_2 and CH_4
- Assess seal integrity
  - Caprock
  - Faults
- Assess the spatial extent of the plume of injected CO_2
- Determine the storage capacity of the reservoir
- Determine the injectivity of the reservoir
- Evaluate environmental impacts
  - Abandoned wells
  - Groundwater

Prioritize Pilot Program

Regulations and Public Outreach

- Experience with permitting pilots projects
  - Department of Oil, Gas and Geothermal Resources
  - US EPA Underground Injection Control Program
- Public outreach
  - State-wide and local information
  - Feedback

Summary

- WestCarb will shortly begin two pilot tests of geological sequestration in California
- Outstanding sequestration potential assessed
- Experience with obtaining permits and regulatory oversight
- Public outreach